UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION III
1650 Arch Street
Philadelphia, Pennsylvania 19103-2029

Mr. Larry Lawson, Director
Division of Water Program Coordination
Virginia Department of Environmental Quality
629 Main Street
Richmond, VA 23219

Dear Mr. Lawson:

The Environmental Protection Agency (EPA) Region III would like to amend its approval of the Nitrate Total Maximum Daily Load (TMDL) for Dry River and Muddy Creek segments VAV-B21R and VAV-B22R. Our original approval for these segments identified the TMDL for the Muddy Creek Watershed. However, the TMDL was developed to account for nitrate loading to the listed Dry River segment as well. Therefore, the TMDL approval should have addressed both streams. A copy of EPA's decision rationale was sent to the Commonwealth with the original approval.

In accordance with Federal regulations at 40 CFR §130.7, a TMDL must comply with the following requirements: (1) designed to attain and maintain the applicable water quality standards, (2) include a total allowable loading and as appropriate, wasteload allocations (WLAs) for point sources and load allocations for nonpoint sources, (3) consider the impacts of background pollutant contributions, (4) take critical stream conditions into account (the conditions when water quality is most likely to be violated), (5) consider seasonal variations,
(6) include a margin of safety (which accounts for uncertainties in the relationship between pollutant loads and instream water quality), (7) consider reasonable assurance that the TMDL can be met, and (8) be subject to public participation. The TMDLs for Dry River and Muddy Creek address all of the requirements listed above.

Following the approval of these TMDLs, Virginia shall incorporate the TMDLs into the Water Quality Management Plan pursuant to 40 CFR § 130.7(d)(2). As you know, all new or revised National Pollutant Discharge Elimination System permits must be consistent with the TMDL WLA pursuant to 40 CFR §122.44 (d)(1)(vii)(B). Please submit all such permits to EPA for review as per EPA's letter dated October 1, 1998.

If you have any questions or comments concerning this letter, please don't hesitate to contact Mr. Thomas Henry at (215) 814-5752.

Sincerely,

Jon M. Capacasa, Acting Director
Water Protection Division

Decision Rationale

Total Maximum Daily Load of
Nitrate for Muddy Creek/Dry River, Virginia

I. Introduction

This document will set forth the Environmental Protection Agency's (EPA) rationale for approving the Total Maximum Daily Load (TMDL) of Nitrate for the Muddy Creek/Dry River submitted for final Agency review on April 7, 2000. Our rationale is based on the TMDL and Addendum provided in the submittal document to determine if the TMDL meets the following 8 regulatory conditions pursuant to 40 CFR §130.

1) The TMDLs are designed to implement applicable water quality standards.
2) The TMDLs include a total allowable load as well as individual waste load allocations and load allocations.
3) The TMDLs consider the impacts of background pollutant contributions.
4) The TMDLs consider critical environmental conditions.
5) The TMDLs consider seasonal environmental variations.
6) The TMDLs include a margin of safety.
7) The TMDLs have been subject to public participation.
8) There is reasonable assurance that the TMDLs can be met.

II. Background

The overall Muddy Creek/Dry River watershed[1], for the purposes of this TMDL analysis, encompasses approximately 77,000 acres and consists of 3 subwatersheds. The Muddy Creek subwatershed area is approximately 20,025 acres with forest and agriculture as the primary land uses. The Upper Dry River, with an area of about 46,711 acres, is over 99% forested. Similar to the Muddy Creek subwatershed, the Lower Dry River subwatershed consists of primarily forested and agricultural land uses and encompasses 10,007 acres. The entire watershed is located about 15 miles to the west-northwest of Harrisonburg, Virginia in Rockingham County. Incidentally, the county has the highest poultry and dairy production levels in the state.

Muddy Creek, a tributary of the Dry River, generally flows southward to its confluence with the Dry River. Eventually, the Dry River flows into North River approximately 2.25 miles downstream of

[1] The Muddy Creek/Dry River watershed is part of the South Fork Shenandoah hydrologic unit (No. 2070005).

the confluence of Muddy Creek and Dry River. The North River then flows into the South Fork of the Shenandoah River, itself a tributary of the Potomac River and Chesapeake Bay.

In response to the requirements of Section 303(d) of the Clean Water Act (CWA), the Virginia Department of Environmental Quality (VA DEQ) listed 7.04 miles of the Muddy Creek/Dry River as being impaired by elevated nitrate levels on the Virginia 1998 303(d) list, specifically with regards to the drinking water use, based on available information[2]. Human health risks associated with elevated nitrate levels include methemoglobinemia (blue-baby disease), which is a potentially fatal blood disorder. The impaired segments include 2.15 miles of Muddy Creek (from a point 0.06 miles above the Route 914 bridge downstream to the confluence with Dry River), 2.56 miles of the lower Dry River (from the confluence with Muddy Creek downstream to the confluence with North River), and 2.33 miles of the North River (from the confluence with the lower Dry River downstream to the City of Bridgewater Water Treatment Plant). VA DEQ listed nitrates from point and nonpoint sources as the cause and sources of impairment, respectively. Muddy Creek, identified as watershed ID VAV-B21R, and Dry River, listed as watershed ID VAV-B22R, were given high priority for TMDL development. Section 303(d) of the CWA and its implementing regulations require a TMDL to be developed for those waterbodies identified as impaired by the State where technology-based and other controls did not provide for attainment of water quality standards. The TMDL submitted by Virginia is designed to determine acceptable levels oftotal nitrogen loading in the Muddy Creek/Dry River watershed, as demonstrated by the Hydrological Simulation Program-Fortran (HSPF)[3], in order to ensure that water quality standards are attained and maintained. These levels of total nitrogen will ensure that the drinking water use is supported. HSPF is considered an appropriate model to analyze this watershed because of it's dynamic ability to simulate both watershed loading and receiving water quality over a range of environmental conditions. Furthermore, VA DEQ ensured that the HSPF model was adequately calibrated to accurately represent both the hydrology and water quality within the watershed.

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[2] Virginia indicates that concerns over elevated nitrate levels were originally expressed by the Town of Bridgewater Water Treatment Plant which was later confirmed by VADEQ monitoring of Muddy Creek and Dry River. In addition, a preliminary modeling study indicated that the nitrate standard would be violated during certain conditions.

[3] Bicknell, B.R., J.C. Imhoff, J.L. Kittle, A.S. Donigan, and R.C. Johanson. 1993. Hydrological Simulation Program-FORTRAN (HSPF): User's Manual for release 10.0. EPA 600/3-84-066. U.S. Environmental Protection Agency, Environmental Research Laboratory, Athens, GA.

Unlike other TMDL analyses for nonpoint source dominated watersheds, the Muddy Creek/Dry River Nitrate TMDL allocates the deposition of total nitrogen to land-based source areas as opposed to allocating edge-of-stream total nitrogen loading from nonpoint source areas. Total nitrogen deposition to land-based sources is modeled as a flux to that land use from liquid dairy manure, poultry litter, fertilizer, grazing animals, atmospheric deposition and wildlife. The HSPF model then determines the amount of total nitrogen loading which reaches stream segments from these source areas. Allocation and control of the total nitrogen loading from flux sources (liquid dairy manure, etc.) to land then becomes an appropriate strategy. Cattle in-stream (only for current conditions) and septic tanks are distinctly modeled as direct deposits to each stream reach. This was seen as appropriate to accurately model the watershed. Wampler Foods, Inc., the only active point source of total nitrogen in the watershed, was also considered as a direct deposition source.

Table 1 below summarizes the specific elements of the TMDL.

Table 1, Summary of Nitrate TMDL (lbs/yr)

Parameter	TMDL	WLA	LA	MOS[1]
Total nitrogen	11,828,214	49,389	11,778,825	Implicit

[1] Virginia includes an implicit MOS by identifying the TMDL target as achieving a total nitrogen water quality concentration of 9.5 mg/l as opposed to the WQS of 10 mg/l. This could be viewed explicitly as a 5% MOS.

EPA believes it is important to recognize the conceptual difference between the WLA values, LA values for sources modeled as direct deposition to stream segments (septic tanks), and LA values for flux sources of total nitrogen to land use categories. The WLA values and LA values for direct sources represent amounts of total nitrogen which are actually deposited into the stream segments. However, LA values for flux sources represent amounts of total nitrogen deposited to land. The actual amount of total nitrogen which reaches the stream segments will be significantly less than the amount of total nitrogen deposited to the land. The HSPF model, which considers landscape processes which affect total nitrogen runoff from land uses, determines the amount of total nitrogen which reaches the stream segments. Tables 4.3 and 4.4 of the Addendum to the TMDL illustrates the actual amounts of total nitrogen which are deposited into stream segments by land use in Muddy Creek and Dry River, respectively.

The United States Fish and Wildlife Service indicated that there are no federally listed threatened and endangered species or designated critical habitat in the segment of Muddy Creek for which this TMDL was developed, via correspondence dated March 06, 2000 (letter) and April 25, 2000 (e-mail).

III. Discussion of Regulatory Conditions

EPA finds that Virginia has provided sufficient information to meet all of the 8 basic requirements for establishing nitrate-nitrogen TMDLs for Muddy Creek/Dry River. EPA therefore approves these TMDLs. Our approval is outlined according to the regulatory requirements listed below.

1) The TMDL is designed to implement the applicable water quality standards.

Virginia has indicated that excessive levels of nitrates due to point and nonpoint sources have caused violations of the water quality standards and designated uses of Muddy Creek/Dry River. As previously mentioned, portions of the North River, Dry River, and Muddy Creek above the City of Bridgewater Water Treatment Plant have been designated as drinking water sources. The water quality criterion for nitrates to support drinking water uses in Virginia is 10mg/l (applicable within 5 miles of a drinking water intake).

The HSPF model is being used to determine the total nitrogen deposition levels to land as well as from point and other direct deposition sources necessary to support the nitrate water quality criterion and drinking water use. The following discussion is intended to describe how control of total nitrogen will ensure that the nitrate-nitrogen water quality criterion is attained and drinking water use restored. The nitrogen cycle involves the conversion of nitrogen gas (N_2) into biologically useful forms and back into nitrogen gas. Figure 1 below illustrates this cycle.

Figure 1
(adopted from *Surface Water-Quality Modeling*, Steven C. Chapra, 1997, page 420)

where: Organic nitrogen (ON) includes things like urea
NH_4^+ - ammonium ion
NH_3 - ammonia
NO_2^- - nitrite
NO_3^- - nitrate

HSPF implicitly considers this nitrogen cycle and the transformation processes as a built-in system both on-land and in-stream. In terms of landscape processes, output from the model includes nitrate and ammonia loadings from each soil zone, sediment nitrogen loadings, and denitrification. Nitrate concentrations in-stream are the key aspect of the water quality model. Processes considered in the model which affect those concentrations include nitrification, denitrification, adsorption to sediment and benthic release of ammonium and orthophosphate, and decomposition of Biochemical Oxygen Demand (BOD) material into ammonia and nitrates.

Total nitrogen is the sum of all speciated forms (ON, NH_3, NO_2^-, NO_3^-) of nitrogen. Furthermore, as seen in the illustration, the ultimate product of the nitrification process is nitrate. Therefore, modeling inputs as total nitrogen and allocating that parameter in order to control nitrates is appropriate because of the nature and final product of the nitrogen cycle and consideration of this cycle within HSPF.

EPA believes that using HSPF to model and allocate total nitrogen will ensure that the designated uses and water quality criterion for Muddy Creek/Dry River will be met and maintained.

2) The TMDL includes a total allowable load as well as individual waste load allocations and load allocations.

Total Allowable Loads

Virginia indicates that the total allowable loading of total nitrogen is the sum of loads allocated to land-based, precipitation-driven nonpoint source areas (forest, developed, farmstead, row crop, pasture 1, pasture 2, pasture 3, loafing lots, barren) from flux sources, directly deposited nonpoint source total nitrogen loads (septic tanks), and one point source (Wampler Foods, Inc.). Activities such as the application of liquid dairy manure, poultry litter and fertilizer as well as contributions from grazing animals (including cattle previously considered direct deposition sources) are considered fluxes to land use categories. The actual value for total nitrogen load deposited can be found in Table 1. The total allowable load is calculated on an annual basis due to the nature of HSPF and the data period which covered multiple years.

Wasteload Allocations

Virginia has stated that there is only one active and significant point source, Wampler Foods, Inc., discharging in the watershed[4]. EPA regulations require that an approveable TMDL include individual WLAs for each point source. According to 40 CFR 122.44(d)(1)(vii)(B), the effluent limitations for an NPDES permit must be consistent with the assumptions and requirements of any available WLA for the discharge prepared by the state and approved by EPA. Furthermore, EPA has authority to object to issuance of an NPDES permit that is inconsistent with WLAs established for that point source. The WLA for Wampler Foods is listed below.

Table 2, Summary of waste load allocations for total nitrogen (lbs/year)

Wampler Foods, Inc.			
NPDES Permit Number VA0002313			
Parameter	**Current loading**	**TMDL loading**	**% reduction needed**
Total Nitrogen	75,984	49,389	35

The point source loads used to represent current conditions were calculated using information gathered from monthly wastewater analysis reports from VA DEQ from 1995 to 1997. The WLA are point source loads which will provide for compliance with the water quality standards previously mentioned.

Load Allocations

According to federal regulations at 40 CFR 130.2(g), load allocations are best estimates of the loading, which may range from reasonably accurate estimates to gross allotments, depending on the availability of data and appropriate techniques for predicting the loading. Wherever possible natural and nonpoint source loads should be distinguished.

[4] Mount Clinton Elementary School does have an NPDES permit, however, it has never discharged and is scheduled to be closed.

In order to accurately simulate landscape processes and nonpoint source loadings, VA DEQ used the HSPF model to represent the Muddy Creek/Dry River watershed. The HSPF model is a comprehensive modeling system for simulation of watershed hydrology, point and nonpoint loadings, and receiving water quality for both conventional pollutants and toxicants[5]. More specifically, HSPF uses precipitation data for continuos and storm event simulation to determine total nitrogen loading to Muddy Creek and Dry River from forest, developed, farmstead, row crops, pasture, barren, and loafing lot lands. The total nitrogen loading from land use categories is the result of the application of liquid dairy manure, poultry litter, fertilizer, grazing animals, atmospheric deposition, and wildlife which is modeled as a flux to land uses[6]. In addition, VA DEQ recognizes the significant total nitrogen loadings which could reach stream segments from numerous septic tanks and large populations of cattle (in-stream). However, contrary to the traditional precipitation-driven, land-based, nonpoint source analysis, these total nitrogen source loadings are directly deposited into stream segments. Therefore, these sources could impact water quality at both low-flow and high-flow conditions. This was done in an effort to more accurately characterize the watershed.

As originally stated, this analysis considers 3 subwatersheds. However, proposed reductions and load allocations are required only for the Muddy Creek subwatershed. VA DEQ states that, even under current loading conditions, water quality standards for nitrate within the Dry River watershed and North River are not violated. This is demonstrated both by available water quality data and predictive modeling. Control scenarios and actions to achieve water quality standards are only necessary for the Muddy Creek watershed. Table 3 below contains the load allocation of total nitrogen applied to land use or source by watershed.

Table 3, Summary of load allocations for total nitrogen deposition to land by watershed

Land Use	Upper Dry River (lbs/yr)	Lower Dry River[1] (lbs/yr)	Muddy Creek[2] (lbs/yr)		
			Current Applied Load	TMDL Applied Load	% reduction
Forest	5,731,252	376,819	845,908	845,908	-
Developed	65,632	173,843	212,019	212,019	-
Farmstead	156	2,500	2,832	2,832	-

[5] Supra, footnote 3.

[6] Tables B.1, B.2, and B.3 of the Addendum illustrates the total nitrogen loads from each of these flux sources to land for the Lower Dry River, Upper Dry River, and Muddy Creek watersheds, respecitvely.

Row Crop	-	659,368	1,057,286	993,853	6[3]
Pasture 1	-	551,524	804,880	728,417	9.5[3]
Pasture 2	-	104,020	117,301	109,676	6.5[3]
Pasture 3	-	503,720	577,740	540,186	6.5[3]
Loafing Lots	-	81,933	156,363	78,180	50[4]
Barren	-	159	32	32	-
Septic tanks[5]	-	6,869	9,927	9,927	-
Cows (in-stream)[6]	-	-	47,577	-[7]	-
Total	5,797,040	2,460,755	3,831,865	3,521,030	6.9

[1] The Lower Dry River is broken down into 2 subwatersheds for modeling purposes.
[2] Muddy Creek is broken down into 8 subwatersheds: Buttermilk, Muddy 1, Muddy 2, Muddy 3, War 1, War 2, War 3, and Patterson. Reductions are applicable in all 8 subwatersheds.
[3] VA DEQ indicates that reductions are necessary only from September through December.
[4] VA DEQ indicates that reduction are necessary from January through December.
[5] Septic tanks are considered direct deposition sources to each stream segment.
[6] Cattle in-stream are considered direct deposition sources to each stream segment.
[7] The reduction of current total nitrogen loading from cows in-stream results from implementation activities from the previously approved Muddy Creek Fecal Coliform TMDL. The reduction involves the elimination of direct deposition of total nitrogen to stream segments and transfers deposition of total nitrogen from cattle to land. Therefore, this load is now implicit in load allocations to land uses.

It is important to keep in mind that the LA values, except those for septic tanks and cattle in-stream, represent total nitrogen deposition to land as opposed to total nitrogen deposition to the stream segment. In addition, those values do not include total nitrogen loading as a result of wet deposition, although this source was considered in the HSPF model.

3) The TMDL considers the impacts of background pollutants.

Background levels represent the chemical, physical, and biological conditions that would result from natural geomorphological processes such as weathering or dissolution[7]. VA DEQ indicates that for the purposes of modeling Muddy Creek/Dry River watershed, background levels of nitrates are the result of septic tanks, wildlife and leaf litter breakdown, and atmospheric deposition. Septic tanks were

[7] Technical Guidance Manual for Developing Total Maximum Daily Loads, Book 2: Streams and Rivers, Part 1: Biochemical Oxygen Demand/Dissolved Oxygen and Nutrients/ Eutrophication. Appendix F. United States Environmental Protection Agency. EPA 823-B-97-002

modeled as separate and distinct sources of total nitrogen while wildlife contributions were considered in the forested land use source and atmospheric deposition of total nitrogen was applied to all land use sources. Therefore, VA DEQ adequately considered background levels of nitrates. In addition, HSPF also considers the interflow and baseflow components of source contributions.

4) The TMDL considers critical environmental conditions.

EPA regulations at 40 CFR 130.7(c)(1) require TMDLs to take into account critical conditions for streamflow, loading, and water quality parameters. The intent of this requirement is to ensure that the water quality of Muddy Creek/Dry River is protected during times when it is most vulnerable.

Critical conditions are important because they describe the factors that combine to cause a violation of water quality standards and will help in identifying the actions that may have to be undertaken to meet water quality standards.[8] Critical conditions are the combination of environmental factors (e.g., flow, temperature, etc.) that results in attaining and maintaining the water quality criterion and has an acceptably low frequency of occurrence. In specifying critical conditions in the waterbody, an attempt is made to use a reasonable "worst-case" scenario condition. For example, stream analysis often uses a low-flow (7Q10) design condition as critical because the ability of the waterbody to assimilate pollutants without exhibiting adverse impacts is at a minimum.

In terms of streamflow, VA DEQ uses data from USGS gage 01621050 (Muddy Creek at Mount Clinton) which recorded observed flows every 15 minutes from 4/13/93 to 12/31/97. This data would represent a range of both low and high flow conditions which are expected to occur in the watershed. Precipitation data from a local climatological station (Dale Enterprise) was also used which would likewise represent a range of precipitation years and conditions that could affect nonpoint source loadings of total nitrogen in the watershed. These data sets are used as the driving mechanism for the HSPF model analysis.

Furthermore, use of the total nitrogen parameter to control nitrate is appropriate due to the nature of the nitrogen cycle and the fact that nitrate is the end product of that cycle.

5) The TMDLs consider seasonal environmental variations.

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[8] EPA Memorandum regarding EPA Actions to Support High Quality TMDLs from Robert H. Wayland III, Director, Office of Wetlands, Oceans, and Watersheds to the Regional Water Management Division Directors, August 9, 1999.

Seasonal variations involve changes in streamflow as a result of hydrologic and climatological patterns. In the continental United States, seasonally high flow normally occurs during the colder period of winter and in early spring from snowmelt and spring rain, while seasonally low flow typically occurs during the warmer summer and early fall drought periods[9]. Consistent with our discussion regarding critical conditions, the HSPF model and TMDL analysis will effectively consider seasonal environmental variations.

6) The TMDLs include a margin of safety.

This requirement is intended to add a level of safety to the modeling process to account for any uncertainty. Margins of safety may be implicit, built into the modeling process, or explicit, taken as a percentage of the wasteload allocation, load allocation, or TMDL.

Virginia includes an implicit margin of safety by establishing the TMDL target water quality concentration for nitrate at 9.5 mg/l, which is more stringent than Virginia's water quality standard of 10 mg/l. This could also be considered an explicit 5% margin of safety.

7) The TMDLs have been subject to public participation.

This TMDL was subject to a number of public meetings. 3 informal meetings were held on August 23, 1999, October 25, 1999, and November 29, 1999 which were intended to address initial questions and concerns regarding outreach issues and the TMDL process. Many of the comments and concerns raised during these meetings served as the basis for revisions to the TMDL. There was also significant interaction with the Muddy Creek Citizens Advisory Group which was originally formed to address the TMDL of Fecal Coliform on Muddy Creek.

The first formal public meeting was held on December 8, 1999 in Dayton and was announced in the Harrisonburg Daily News-Record on December 2, 1999. Two additional formal public meetings on March 20, 2000 and April 4, 2000 were also necessary in order to select an allocation scenario which could provide reasonable assurance as required by federal regulation. No written comments or responses were provided by VA DEQ with this submission.

8) There is a reasonable assurance that the TMDL can be met.

[9] Supra footnote 6, Section 2.3.3.

EPA requires that there be a reasonable assurance that the TMDL can be implemented. WLAs will be implemented through the NPDES permit process. According to 40 CFR 122.44(d)(1)(vii)(B), the effluent limitations for an NPDES permit must be consistent with the assumptions and requirements of any available WLA for the discharge prepared by the state and approved by EPA. Furthermore, EPA has authority to object to issuance of an NPDES permit that is inconsistent with WLAs established for that point source.

Nonpoint source controls to achieve LAs can be implemented through a number of existing programs such as Section 319 of the Clean Water Act, commonly referred to as the Nonpoint Source Program. Additionally, Virginia's Unified Watershed Assessment, an element of the Clean Water Action Plan, could provide assistance in implementing this TMDL.